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..	not available for a specific reference period
...	not applicable
0	true zero or a value rounded to zero
0[s]	value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
[p]	preliminary
[r]	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
[E]	use with caution
F	too unreliable to be published
*	significantly different from reference category ($p < 0.05$)

Gender gaps — Life expectancy and proportion of life in poor health

by Marc Luy and Yuka Minagawa

Abstract

Background
The literature suggests that women report worse health but live longer than men—a phenomenon known as the gender paradox in health and mortality. Although studies examining the paradox abound, relatively little is known about mechanisms underlying the gap.

Data and methods
With data on healthy life expectancy from the Global Burden of Disease Study 2010, this article analyses the relationship between length of life and health among men and women in 45 more-developed countries. The proportion of life spent in poor health is used as an indicator of health. This approach accounts for gender differences in longevity and illustrates the female health disadvantage pattern more clearly.

Results
Life expectancy at birth and and the proportion of life in poor health are closely related for both genders. Furthermore, the larger the female excess in longevity, the larger the female excess in the proportion of life in poor health.

Interpretation
By focusing on the proportion of life in poor health, this analysis suggests that women's longevity advantage translates into a health disadvantage relative to men. The results indicate that women suffer from poor health not in spite of living longer, but because they live longer.

Keywords
Gender differences, health expectancy, morbidity, mortality, world health

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In the 1920s, a pattern began to emerge in the health and mortality of men and women: as described by Lorber and Moore,[1] "Women get sicker, but men die quicker." Although men's mortality rate exceeds that of women at all ages,[2] women tend to report worse health.[3] Even excluding reproductive conditions, a sizeable gender difference remains in the prevalence of acute conditions and short-term disability.[4] Older women exhibit greater rates of decline in physical functioning, are less likely to recover from disability, and more frequently report pain.[5,6] Some studies find that women use health care services[7] and prescription and non-prescription drugs[8] more often than men do. These observations have prompted a great deal of research, construing the phenomenon as the "gender and health paradox,"[9] the "paradox of 'weak but strong women' and 'tough but weak men,'"[10] or the "male-female health-survival paradox."[11]

Several hypotheses to explain the paradox have been proposed. Two of the most pervasive provide coherent explanations based on the association between health and mortality. According to the first, as a consequence of interactions among biological, social, psychological and behavioural factors,[12] men and women suffer from different types of illnesses. Women report health problems more frequently, but these conditions tend to be less severe and lethal than those from which men tend to suffer.[13-15] According to the second hypothesis, women, on average, live longer, a gap that translates into health inequalities between men and women. Previous work has found that women's longer lives are accompanied by increases in morbidity, and has concluded that women's longevity advantage itself is an important contributor to their health disadvantage.[16-18]

Based on the best available cross-national data on health expectancy for 45 more-developed countries, the present study provides further support for the second hypothesis—namely, that women's longevity advantage is a major

contributor to their health disadvantage. Most research on this topic has examined the absolute number of unhealthy years, but has neglected the fact that men and women have different life expectancies. Because life expectancy (LE) is, on average, longer among females than among males, the gap in LE should lead to more years in poor health for women, even if men and women have identical distributions of health. The present study focuses on the proportion of life spent in poor health. This relative perspective accounts for gender differences in length of life and offers a more comprehensive picture of the gender gap in health and mortality.

Data and methods

This analysis is based on data from the Global Burden of Disease (GBD) study in 2010, a collaborative international effort to systematically describe the world's distribution of diseases, injuries, and health risk factors.[19] Using numerical weights ranging from 0 (perfect health) to 1 (death), the study quantifies the comparative magnitude of health loss due to 291 diseases and injuries; 1,160 sequelae of these diseases and injuries; and 67 risk factors or clusters of risk factors across 187 countries (the full list of diseases, risk factors, and sequelae is published elsewhere[20]). Data on the prevalence of each condition and risk factor come from a range of studies and sources, such as national health surveys and international databases. The GBD 2010 reports results with disability-adjusted life years (DALYs), which is the sum of life years lost due to premature death and to time lived with disability.[20] Disability is defined as short- or long-term health loss, other than death, such as chronic respiratory disease, diabetes, cardiovascular diseases, and mental or behavioural disorders. Using DALYs, the GBD 2010 estimates the number of years that a person at a given age can expect to live in good health—health-adjusted life expectancy (HALE), or healthy life expectancy (HLE).

The present study uses HLE data published in 2010.[21] Because many reports on the gender paradox come from industrialized societies where chronic conditions are more prevalent, the sample is limited to the 45 countries classified by the United Nations as "more-developed": 40 countries in Europe; 2 in North America (the United States and Canada); and Australia, New Zealand and Japan (Appendix Table A contains the complete list of countries).

This analysis has two parts. The first examines the relationship between health and length of life for women and men. Data about gender-specific LE at birth and HLE at birth are combined, and the proportion of life in poor health ((LE - HLE/LE) is calculated. The second part of the analysis investigates the extent to which women's health disadvantage (gender differences in the proportion of life spent in poor health, females minus males) is related to their longevity advantage (gender differences in LE at birth, females minus males). Using the relative amount of life years spent in poor health throughout the analyses accounts for the gender gap in longevity, and thus, more clearly demonstrates women's health disadvantage relative to men.

Ordinary least square (OLS) regression analyses are used to clarify relationships between health and mortality. First, the association between LE at birth (independent variable) and the proportion of life spent in poor health (dependent variable) is estimated for each gender. Then, the way in which gender differences in proportions of poor health (dependent variable) and in LE at birth (independent variable) are related to each other is tested. Japan, Iceland and Montenegro were identified as influential observations that combine large residuals and higher levels of leverage. Because these data points can have a strong influence on the estimated slope, supplemental analyses were conducted that adjust for these observations in regression models. No differences emerged when the results with and without these countries were compared. Therefore, results are reported without adjusting for influential points. All analyses were performed with Stata 12.0.[22]

Although biological "sex" plays a role in shaping the health of men and women, given that health differentials between men and women are largely influenced by socially constructed "gender,"[12] the term "gender" is used throughout this article to address observed differences in men's and women's mortality and morbidity.

Results

In 2010, average LE at birth in the 45 more-developed countries was 74.7 years for men and 81.0 years for women, a difference of 6.3 years (Table 1). Women also spent more years in a good health—the gender difference in HLE was 4.7 years. Thus, compared with men, women not only live more years overall, but also, more years in good health. However, when results are converted into relative values, women spend a greater proportion of their lives in poor health. In 2010, men could expect to live 13.3% of their lives in poor health, compared with 14.3% for women.

For both men and women, positive and strong relationships are evident between LE at birth and the proportion of life in poor health (Figures 1 and 2)—the longer the LE at birth, the higher the proportion of life in poor health. Correlation statistics are 0.545 ($p < 0.001$) among

Table 1
Mean life expectancy at birth, healthy life expectancy at birth, and proportion of life in poor health, by gender, 45 more-developed countries, 2010

	Men	Women	Difference (women - men)
Life expectancy at birth (years)	74.7 (4.60)	81.0 (2.94)	6.3
Healthy life expectancy at birth (years)	64.7 (3.68)	69.4 (2.35)	4.7
Proportion of life in poor health (%)	13.3 (0.94)	14.3 (0.87)	1.0

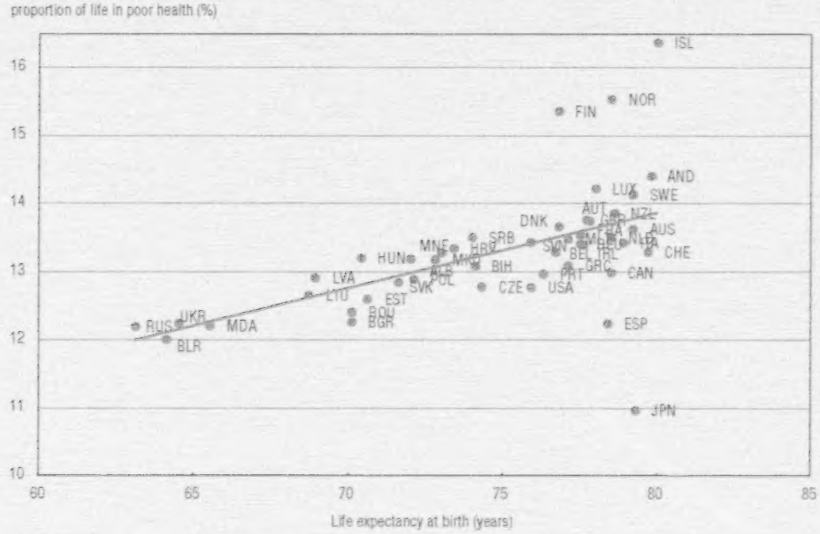
Note: Standard errors are in parentheses.
Sources: Global Burden of Disease 2010 Study.

men and 0.388 ($p < 0.01$) among women. Lines of fitted values clearly illustrate positive associations between these two indicators.

OLS regression analyses, using the proportion of life in poor health as the dependent variable and LE at birth as the independent variable (Table 2) further confirm significant relationships between them for both men and women. Among men, a one-year increase in LE at birth is associated with an increase in the proportion of life in poor health by 0.11 ($p < 0.001$). Among women, for every one-year increase in LE at birth, the proportion of life in poor health rises by 0.12 ($p < 0.01$).

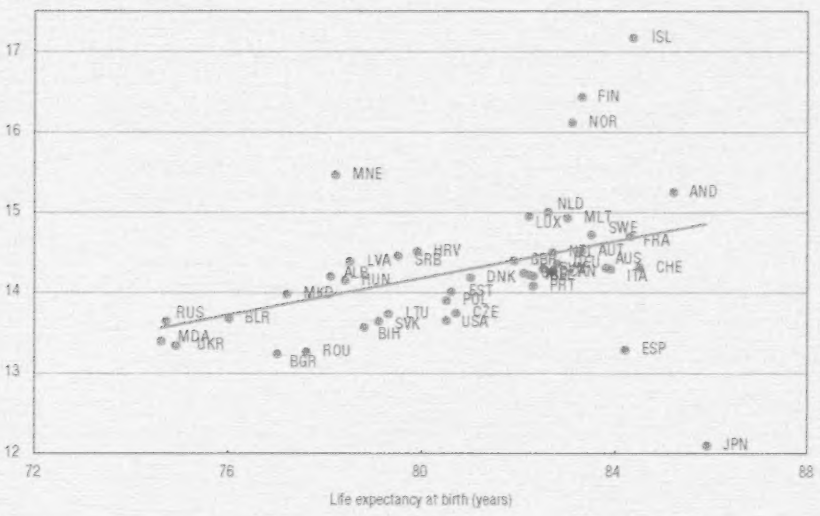
Furthermore, the wider the gender gap in LE at birth, the larger the gender gap in the proportion of life in poor health (Figure 3). The correlation between these two variables is 0.473 ($p < 0.001$). Thus, a greater disparity in longevity is accompanied by an increase in the relative female disadvantage in health. Results of OLS regression models substantiate the strong and positive relationship between the gender gap in longevity (independent variable) and the gender gap in the proportion of life in poor health (dependent variable) (Table 2). For every one-year increase in the gender gap in LE at birth, women's excess in the proportion of life in poor health rises by 0.07 ($p < 0.001$). Taken together, the female excess in poor health seems to be a function of the female advantage in LE.

Figure 1
Male life expectancy at birth and proportion of life in poor health, 45 more-developed countries, 2010



correlation r = 0.545, $p < 0.001$
Note: Appendix Table A contains country abbreviations.
Source: Global Burden of Disease 2010 Study.

Figure 2
Female life expectancy at birth and proportion of life in poor health, 45 more-developed countries, 2010



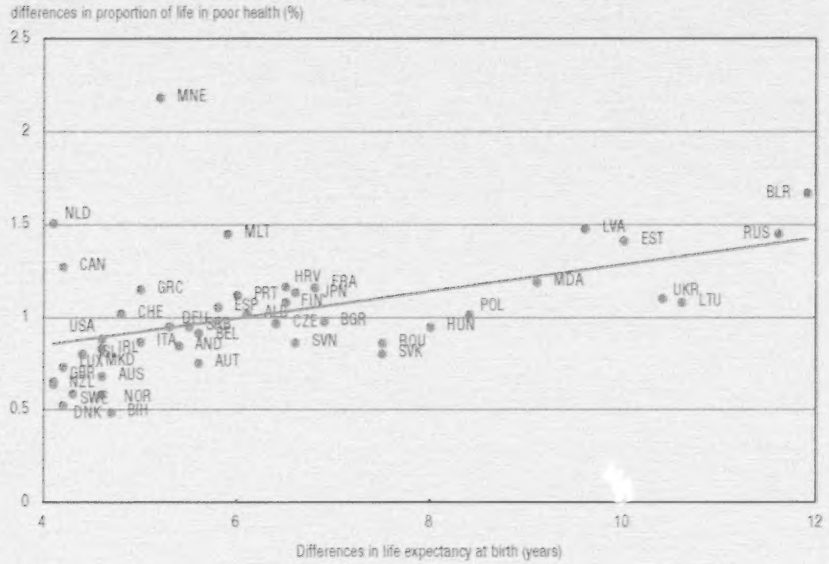
correlation r = 0.388, $p < 0.01$
Note: Appendix Table A contains country abbreviations.
Source: Global Burden of Disease 2010 Study.

Discussion

Although higher morbidity is associated with higher mortality,[23-25] the relationship does not hold up when gender differences are examined. Women report poorer health, but live longer than men.

The literature contains several explanations for this paradox, among them, that women are more sensitive to bodily discomforts,[26] are more willing to report health problems,[27,28] and are more likely to engage in preventive health behaviour.[29] Results, however, have not been conclusive. Some studies find no gender differences in levels of pain and in reporting behaviour,[30,31] while others show that men are more likely than women to complain about their health.[32] Analysis by Oksuzyan et al.[11] reveals that among people who are hospitalized, women are more likely than men to participate in surveys, but selection bias cannot fully explain gender differentials in health and mortality. Furthermore, evidence about gender differences in the use of health care services can be contradictory.[33]

Figure 3
Female-Male differences in life expectancy at birth and proportion of life in poor health, 45 more-developed countries, 2010



correlation r = 0.473, p < 0.001
Note: Appendix Table A contains country abbreviations.
Source: Global Burden of Disease 2010 Study.

Table 2
Estimates of ordinary least squares regression models for 45 more-developed countries, 2010

Model	Men	Women
(1) Life expectancy (LE) at birth	.11***	.12**
(2) Gender differences in LE at birth	.07***	

**p < 0.01
***p < 0.001
Note: Model (1) estimates relationship between LE at birth (independent variable) and proportion of life in poor health (independent variable). Model (2) estimates relationship between gender differences in LE (women minus men, independent variable) and gender differences in proportion of life in poor health (women minus men, dependent variable).
Source: Global Burden of Disease 2010 Study.

Among the most consistent findings are differences in the types and severity of conditions experienced by men versus women.[14] Women generally suffer from more conditions than men do, but female ailments tend to be less lethal. By contrast, men suffer from conditions that lead to earlier death.[3,26,34] As well, the prevalence and consequences of the diseases differ. Conditions such as allergies, headaches or arthritis—illnesses that are more common among women—have high prevalence but low mortality; others—namely, heart disease and the most severe forms of cancer, all being more frequent in men—have relatively low prevalence but high mortality.[16] These observations raise the possibility that the gender paradox is primarily due to differences in the types of conditions experienced by men and women.

In addition, women's longer average LE itself is likely to influence male-female differences in health status. Prior research demonstrated that the longer lives of women are the reason they spend more years with morbidity.[11,16] Studies to date, however, tended to analyze the absolute number of years in poor health. A more accurate understanding can be gained through proportional analysis—years in poor health in relation to the overall length of life.

The current study examined gender differences in the proportion of life in poor health, and hypothesized that women's living longer is a major contributor to their health disadvantage relative to men. Based on data for the 45 countries classified by the United Nations as "more-developed," longer LE at birth is strongly associated with greater proportions of life in poor health for both genders. Furthermore, the larger the female excess in longevity, the larger the female excess in the proportion of life in poor health. Proportional analysis, therefore, supports the hypothesis that women's longevity advantage is directly related to their health disadvantage. In other words, women have poorer health not in spite of living longer, but because they live longer.

This reasoning relates the gender paradox to the general relationship between morbidity (health status) and mortality (length of life). As outlined in the epidemiologic transition theory,[35] a shift in the prevalence of diseases over time (from fatal to less serious conditions) led to improvements in longevity around the globe. A rise in less-severe yet long-lasting health problems—chronic diseases—can result in more, but comparatively less healthy years of life as described in the "expansion of morbidity" hypothesis.[36] That is, increasing LE is caused by a reduction in the fatality rate of chronic diseases rather than by a decline in the prevalence of these diseases.[37]

Contrariwise, Fries[38] proposed the "compression of morbidity" hypothesis. According to this hypothesis, while the average maximum lifespan remains fixed at around 85 years, the onset of chronic diseases will be postponed, and morbidity will be compressed into a shorter period at the end of life.

Finally, Manton outlined the idea of a balanced relationship between health and longevity which is referred to as the "dynamic equilibrium hypothesis."[39]

Although there is no support for a fixed human lifespan,[40] some research supports the compression of morbidity thesis. Most of these studies focus on the prevalence of disability; it remains to be

What is already known on this subject?

- The literature shows that women report worse health but live longer than men.
- A large number of studies have examined this paradox, but relatively little is known about the mechanisms underlying it.
- One line of research suggests that women's longer life expectancy itself translates into their health disadvantage compared with men.
- Most research has focused on the absolute number of unhealthy years, thereby neglecting the fact that men and women have different life expectancies.

What does this study add?

- This analysis examined gender differences in the proportion of life spent in poor health, and hypothesized that women's longevity is a major contributor to their health disadvantage relative to men.
- Based on data for the 45 countries classified as "more-developed," longer life expectancy at birth is strongly associated with greater proportions of life in poor health for both genders.
- The larger the female excess in longevity, the larger the female excess in the proportion of life in poor health.
- Proportional analysis supports the hypothesis that women's longevity advantage contributes significantly to their health disadvantage.

determined if the same conclusion would be drawn when other types of conditions are considered.[41] Crimmins and Saito,[42] for example, reported that between 1984 and 1994, the prevalence of disease and comorbidity among older women in the United States increased, even though disability decreased. Also, some studies have found reductions in disability accompanied by simultaneous increases in chronic disease and functional impairments.[43] Thus, studies of disability seem to support the compression of morbidity hypothesis because of recent improvements in the indicator, whereas those focusing on chronic conditions or measures of comorbidity find evidence for the expansion of morbidity hypothesis.

At a first glance, the present study appears to support the expansion of morbidity hypothesis. For two reasons, however, the findings do not imply that the expansion of morbidity is a universal phenomenon. First, the expansion versus compression discussion emerges from a longitudinal perspective examining whether increases in length of life are accompanied by better or worse health. By contrast, the present study employs a cross-sectional study design and tests the extent to which gender differences in LE at birth were related to gender differences in the proportion of life in poor health in 2010. Second, the health measures used in the GBD study include a wide array of chronic conditions, which might be why the results of this analysis seem to be in line with the expansion of morbidity thesis. However, other health measures might yield different results. The choice of health measure has an important bearing on the gender paradox as well, because gender differences in health vary by how health is measured.[9,16,44]

Limitations

The current study has several strengths: the interpretation of health expectancy measures in relative terms, a focus on multiple dimensions of health, and the extensive number of countries included in the analysis. However, the findings should be interpreted with caution.

The first limitation concerns the reliability of health measures. The GBD study quantifies the burden of specific health conditions and risk factors, but the underlying methodological strategy, namely, numerical weights assigned to each condition, has been questioned.[45] Further, computations of the prevalence rates of health conditions are based on more than 100,000 data sources, including hospital discharge data, disease registries, and household surveys; the quality and validity of data differ by country. Moreover, cross-national comparisons of health are challenging, because results are often influenced by cultural variations in the interpretation of questions and response categories, and/or different health standards across countries.[46]

The second caveat concerns age. Health expectancy indicators in the GBD study are measured only at birth, making it impossible to examine how the relationship between morbidity and mortality changes with age. Most studies estimate health expectancy at advanced ages. Differences in age range make it difficult to directly compare the results of this analysis with those of other studies. Further research based on more differentiated age-specific health expectancy measures would clarify dynamic processes associated with aging.

Finally, the present findings only suggest associations between morbidity and mortality. Strong positive relationships between LE at birth and the proportion of life in poor health emerged across 45 countries, but the extent to which morbidity and mortality contribute to gender differences in HLE remains unknown. Answering this question requires research that decomposes the differences in health expectancy into the effects of mortality and health conditions, as shown by Van Oyen et al.[47] Future research might examine how morbidity and mortality translate into varying experiences of health among men and women.

Conclusion

Gender differences in health and mortality have been the subject of considerable research across disciplines, but the mechanisms underlying this phenomenon have not been firmly established. The most consistent finding is that women and men differ in the kinds and severity of diseases. These differences likely explain a large part of the gender gap in health. Results of the analysis of the GBD estimates suggest that women's living longer is also a significant contributor to their poorer heath relative to men. Through proportional analyses, this study finds that longer lives are accompanied by increases in the proportion of life spent in poor health, and concludes that women suffer from worse health than men do not in spite of living longer, but because they live longer. Gender differences in health and mortality are complex, but a relative analysis of health expectancy makes the gender-health paradox far less paradoxical. ■

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Appendix

Table A

Life expectancy (LE) at birth, healthy life expectancy (HLE) at birth, and proportion of life in poor health, by gender, 45 more-developed countries, 2010

Country name (country code)	Men			Women			Difference in % of LE in poor health (7)-(4)
	LE (years)	HLE (years)	% of LE in poor health	LE (years)	HLE (years)	% of LE in poor health	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Albania (ALB)	72.0	62.5	13.19	78.1	67.0	14.21	1.02
Andorra (AND)	79.8	68.3	14.41	85.2	72.2	15.26	0.85
Australia (AUS)	79.2	68.4	13.64	83.8	71.8	14.32	0.68
Austria (AUT)	77.7	67.0	13.77	83.3	71.2	14.53	0.75
Belarus (BLR)	64.1	56.4	12.01	76.0	65.6	13.68	1.67
Belgium (BEL)	76.7	66.5	13.30	82.3	70.6	14.22	0.92
Bosnia and Herzegovina (BIH)	74.1	64.4	13.09	78.8	68.1	13.58	0.49
Bulgaria (BGR)	70.1	61.5	12.27	77.0	66.8	13.25	0.98
Canada (CAN)	78.5	68.3	12.99	82.7	70.9	14.27	1.27
Croatia (HRV)	73.4	63.6	13.35	79.9	68.3	14.52	1.17
Czech Republic (CZE)	74.3	64.8	12.79	80.7	69.6	13.75	0.97
Denmark (DNK)	76.8	66.3	13.67	81.0	69.5	14.20	0.53
Estonia (EST)	70.6	61.7	12.61	80.6	69.3	14.02	1.41
Finland (FIN)	76.8	65.0	15.36	83.3	69.6	16.45	1.08
France (FRA)	77.5	67.0	13.55	84.3	71.9	14.71	1.16
Germany (DEU)	77.5	67.1	13.42	82.8	70.9	14.37	0.95
Greece (GRC)	77.1	67.0	13.10	82.1	70.4	14.25	1.15
Hungary (HUN)	70.4	61.1	13.21	78.4	67.3	14.16	0.95
Iceland (ISL)	80.0	66.9	16.38	84.4	69.9	17.18	0.81
Ireland (IRL)	77.6	67.2	13.40	82.2	70.5	14.23	0.83
Italy (ITA)	78.9	68.3	13.43	83.9	71.9	14.30	0.87
Japan (JPN)	79.3	70.6	10.97	85.9	75.5	12.11	1.14
Latvia (LVA)	68.9	60.0	12.92	78.5	67.2	14.39	1.48
Lithuania (LTU)	68.7	60.0	12.66	79.3	68.4	13.75	1.08
Luxembourg (LUX)	78.0	66.9	14.23	82.2	69.9	14.96	0.73
Macedonia (MKD)	72.8	63.2	13.19	77.2	66.4	13.99	0.80
Malta (MLT)	77.1	66.7	13.49	83.0	70.6	14.94	1.45
Moldova (MDA)	65.5	57.5	12.21	74.6	64.6	13.40	1.19
Montenegro (MNE)	73.0	63.3	13.29	78.2	66.1	15.47	2.19
Netherlands (NLD)	78.5	67.9	13.50	82.6	70.2	15.01	1.51
New Zealand (NZL)	78.6	67.7	13.87	82.7	70.7	14.51	0.64
Norway (NOR)	78.5	66.3	15.54	83.1	69.7	16.13	0.58
Poland (POL)	72.1	62.8	12.90	80.5	69.3	13.91	1.01
Portugal (PRT)	76.3	66.4	12.98	82.3	70.7	14.09	1.12
Romania (ROU)	70.1	61.4	12.41	77.6	67.3	13.27	0.86
Russia (RUS)	63.1	55.4	12.20	74.7	64.5	13.65	1.45
Serbia (SRB)	74.0	64.0	13.51	79.5	68.0	14.47	0.95
Slovakia (SVK)	71.6	62.4	12.85	79.1	68.3	13.65	0.80
Slovenia (SVN)	75.9	65.7	13.44	82.5	70.7	14.30	0.86
Spain (ESP)	78.4	68.8	12.24	84.2	73.0	13.30	1.06
Sweden (SWE)	79.2	68.0	14.14	83.5	71.2	14.73	0.59
Switzerland (CHE)	79.7	69.1	13.30	84.5	72.4	14.32	1.02
United Kingdom (GBR)	77.8	67.1	13.75	81.9	70.1	14.41	0.65
Ukraine (UKR)	64.5	56.6	12.25	74.9	64.9	13.35	1.10
United States (USA)	75.9	66.2	12.78	80.5	69.5	13.66	0.88

Source: Global Burden of Disease 2010 Study.